OIL SHALE

and the MINERALS MANAGEMENT SERVICE

U.S. DEPARTMENT OF THE INTERIOR
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This booklet is intended to serve as an introduction to the Department of the Interior's Prototype Oil Shale Leasing Program and, specifically, the role of the Minerals Management Service in administering the program. It was prepared by the Training Development Section, Lakewood, Colorado, with the help of the Oil Shale Office, Grand Junction, as a supplement to the Minerals Management Service's oil shale training orientation course. The booklet may be used in conjunction with the slide/tape presentation on this subject, as a followup review and as a handy future reference.

The Role of Minerals Management Service in the U.S. Department of the Interior's Prototype Oil Shale Leasing Program

U. S. DEPARTMENT OF THE INTERIOR

MINERALS MANAGEMENT SERVICE

Introduction

The existence of oil shale has been known for centuries in many parts of the world. In this country, Indians used it for fuel. And it's said that an early settler once built a cabin for his new bride with a large stone fireplace. The first use of the fireplace was at a housewarming party when the roaring fire consumed not only the logs, but the fireplace and cabin as well.

The fireplace had been built with some nice, flat rocks from a nearby hillside . . .

Oil shale.

While oil shale is distributed throughout the world, the United States has one of the largest deposits. Deposits in the eastern part of the nation are extensive; but the Green River formation deposits in Colorado, Utah, and Wyoming which cover about 10 million acres contain the largest defined hydrocarbon resources in the world.

It wasn't until the 1930's, following a Presidential order to withdraw all valuable oil shale lands for evaluation and classification, that the extent and quality of U.S. oil shale deposits were known.

With the realization that 80 percent of the oil shale was on Federal lands and that some of the best oil shale anywhere was included in those deposits, the Department of the Interior—custodian of the public lands — set about implementing a national policy to study and encourage testing of oil shale development. This led to the Department's Prototype Oil Shale Leasing Program, instituted in 1971 and carried out today by the Minerals Management Service as part of its lease supervision duties.

The program's overall purpose is to encourage private industry to develop oil shale mining and processing technology on a commercial scale, while at the same time developing economic and environmental information along with environmental safeguards.

An early oil shale retort near De Beque, Colorado.

History of Oil Shale

As its name implies, the Prototype Oil Shale Leasing Program is the first of its kind and is designed to serve as a model for future oil shale leasing on Federal lands. It is a relatively new program for the Minerals Management Service (formerly the Conservation Division of the Geological Survey), which has supervised mineral development on Federal and Indian lands for more than half a century.

Shale oil production itself, however, has been around for nearly three centuries. As early as 1694, a British Crown patent records a method to distill "oyle from a kind of stone." The first commercial production of shale oil began in France in 1838. The shale oil industry of Scotland dating back to 1850 produced oil that was used primarily as a lubricant for spindles in the weaving industry.

The oil was extracted from the rock by applying heat — a process known today as "retorting."

Retorting of oil shale in this country began on small scale a few years before the discovery of oil in Pennsylvania. But that State's famous Drake oil well discovery in 1859 began a tradition that made shale oil a bridesmaid to conventional crude oil. Each time it looked like an oil shale industry would get on its feet, a major oil field was discovered offering a cheaper source of petroleum and thus precluding oil shale development.

A revival of interest in oil shale began shortly after the start of this century. Early oil shale operations in the western Green River shale used crude surface retorts located where the oil shale outcropped. Mining operations ranged from breaking chunks off the outcrop to sinking shallow shafts.

Early oil shale development in the Green River Formation involved breaking chunks off of outcrops. Circa 1915.

Legislative History

Before 1920, these oil shale operations came under the General Mining Law of 1872, whereby large blocks of oil shale claims could be staked. But in 1920, the Mineral Leasing Act made oil shale, along with certain other minerals on Federal lands, a leasable mineral, authorizing the Secretary of the Interior to lease oil shale lands and to collect royalties on production from those lands.

Research, as well as European production, had shown that shale oil could be extracted in commercial quantities. But only by constructing and operating a commercial-sized facility could it be proved feasible under existing market conditions.

Economic and environmental concerns have been the greatest challenges to commercial oil shale development. So, in 1971, the Department of the Interior announced a Prototype Oil Shale Leasing Program to test the environmental and economic feasibility of the various oil shale development technologies at commercial scale.

Satellite imagery of northwestern Colorado. Piceance Creek Basin is near the center, a 1,900-square-mile area underlain by the richest oil shale deposit in the U.S.

Prototype Oil Shale Program Objectives

Four specific objectives were identified in the Prototype Oil Shale Leasing Program:

- To provide a new energy source for the country by stimulating development of oil shale technology;
- To protect the environment of lease tracts, and develop environmental safeguards;
- To permit a fair return on resource development for industry and the Government by developing economic data; and
- To develop expertise in administering and managing the oil shale leasing program for the Department.

Leasing (Objective No. 1)

To meet these four objectives, the Interior Department began, in 1971, by requesting tract nominations from private industry for oil shale leases. Of the 20 tracts nominated, six were offered for competitive bidding — two each in Colorado, Wyoming, and Utah.

While the Wyoming tracts received no bids, and thus were not leased, the Colorado and Utah tracts were leased in 1974, and are known today as leases C-a, C-b, U-a, and U-b, respectively. Each tract covers about 5100 acres, and bonus bids for all four tracts totaled nearly $450 million.

In June of the same year, an Oil Shale Office was established in the Minerals Management Service to administer these leases. Its multidisciplinary staff consists of specialists in the fields of mining, geology, meteorology, air quality, hydrology, wildlife, reclamation, chemistry, and systems analysis. The office is located in Grand Junction, Colorado, in the heart of oil shale country.

Detailed Development Plans

A major task of this staff is to review and approve Detailed Development Plans required from lessees for each of the four lease tracts. Frequently revised by lessees, the plans describe exactly how the lessee plans to develop a lease to commercial production and how environmental requirements will be met. The Oil Shale Office also reviews and approves revisions to the plans.

In reviewing these plans, the Oil Shale Office also checks to see that the requirement of "diligent development" will be met. Diligence means lessees must develop and bring their leases to production in an expeditious and timely manner.

Each plan also has to be reviewed in light of the overall Environmental Impact Statement for the prototype leasing program, published in 1973. In addition to the technical review and final approval by the Oil Shale Office, Detailed Development Plans are also given public scrutiny, and valid comments are incorporated.

View northward along Hells Hole Canyon east of tract U-b in eastern Utah. Here oil shales of the upper Green River Formation outcrop near the canyon bottom.

Detailed Development Plans were required for each lease by the close of the third lease year, and by 1977 plans for the two Colorado tracts were approved. A court injunction on the Utah tracts delayed final review and approval of those plans until questions of Federal-State land ownership and pre-1920 mining claims could be resolved. By March 1982, the court injunction had been lifted and a joint development plan was approved for the two Utah tracts.

Early spring runoff from snowmelt in the Piceance Creek Basin. Of the annual 14 to 17 inches of precipitation in the area, snowfall accounts for about 40 percent, with the remainder falling mostly during brief but intense thunderstorms.

Environmental Safeguards (Objective No. 2)

Various methods of mining and retorting oil shale and disposing of the processed shale are proposed in the Development Plans and are in various stages of testing. All will affect the air, water, land, plant and animal life, and socioeconomic structure of the surrounding area, and raise questions of how these environmental effects can be detected, measured, and mitigated when commercial-scale operations begin.

Environmental Monitoring

To answer these questions, each lessee was required to monitor the environment of each lease tract for a 2-year period to establish baseline (background) data from which changes in the environment due to oil shale development could be detected.

Lessees submitted both baseline and development monitoring plans to the Oil Shale Office for technical review and approval. In addition, an Oil Shale Environmental Advisory Panel — an interagency organization made up of Federal, State, and local officials plus citizen members — reviews the environmental aspects of these plans and advises the Oil Shale Office. Other Federal and State agencies include the Environmental Protection Agency, the Colorado Department of Health, and the Utah Division of Health.

Air quality monitoring is designed to continuously measure such things as oxides of nitrogen, ozone, and sulfur dioxide. Meteorological monitoring includes ground-level measurements for wind speed and direction, temperature, humidity, visibility, and solar radiation, as well as sampling of the upper atmosphere. Other regimes such as water and biology are monitored with equal intensity.

Interestingly, results of the 2-year environmental baseline air quality studies show that even Mother Nature in this part of the country sometimes doesn't meet the exacting standards established by the Federal Government for air quality. Measured ozone levels have exceeded those permitted by Federal standards, and high particulate readings, primarily due to blowing dust, have been observed on the Colorado tracts.

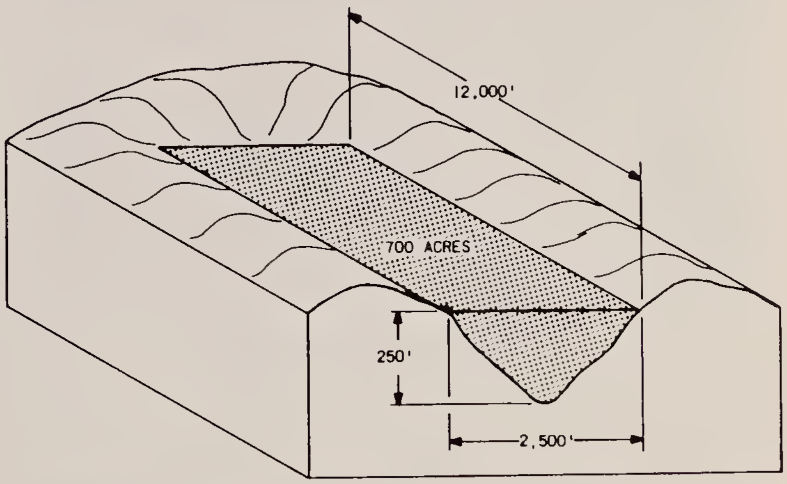
Environmental monitoring on oil shale leases is an ongoing, ever-changing effort and will separate those changes in the environment caused by development from changes caused by nature.

Rawinsonde carries meteorological instruments for air quality studies on the Utah tracts.

Mitigating Environmental Impacts

A second element in the prototype program's environmental objective is to devise ways to mitigate unavoidable environmental damage. In this effort, the Oil Shale Office is working with lessees and other agencies on such matters as mitigating surface disturbance, providing new water holes to draw wildlife into areas they previously shunned, and fertilizing and irrigating some areas to increase forage.

Other examples include reinjection of produced ground water to limit the spread of aquifer drawdown and prevent springs from drying up, and adjusting waste disposal designs to permit early reclamation and revegetation.



Disposing of spent shale after surface retorting would involve placing it in natural depressions, such as this hypothetical canyon, covering it with native soil, and seeding it with a suitable ground cover.

Aerial view of gas processing facilities on lease C-a.

Economics (Objective No. 3)

The third objective of the Prototype Oil Shale Leasing Program — to permit a fair return on resource development by obtaining economic data — can only be achieved after operation of a commercial shale oil plant to determine once and for all the real economics of oil shale development. But the problem facing private industry is justifying and obtaining the huge amounts of front-end money and capital investment needed to construct the facility without knowing if an equitable return can be made on the investment.

To assist in this dilemma, oil shale lease terms allow private industry to credit certain construction costs against the lessee's bonus bid to lease the tract. Certain costs may also be credited against production royalties due the Government. Efforts by industry and others to obtain further incentives are continuously being considered.

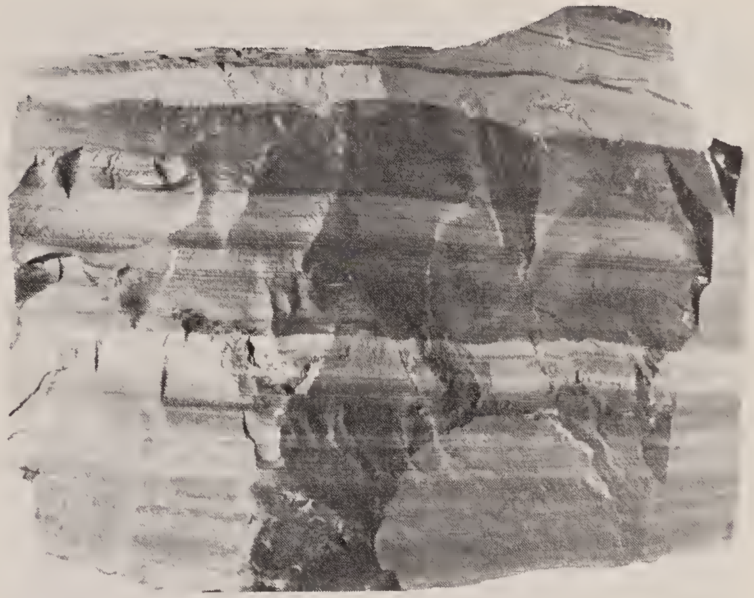
Actual construction on the two Colorado leases began in fall of 1977, and some shale oil has been produced from one of the leases, primarily on an experimental basis. Work at the Utah tracts began after approval of the Detailed Development Plans in 1982 and has involved road construction, site preparation, and mine shaft sinking to develop a commercial-size room-and-pillar mine.

The Colorado and Utah tracts will use somewhat varying techniques for developing the oil shale. While retorting employs the same basic process—applying sufficient heat, just as it was done centuries ago—the methods of doing this have grown with modern technology and are in various stages of testing.

To understand how these retorting methods work, it is important to know what oil shale is.

What is Oil Shale?

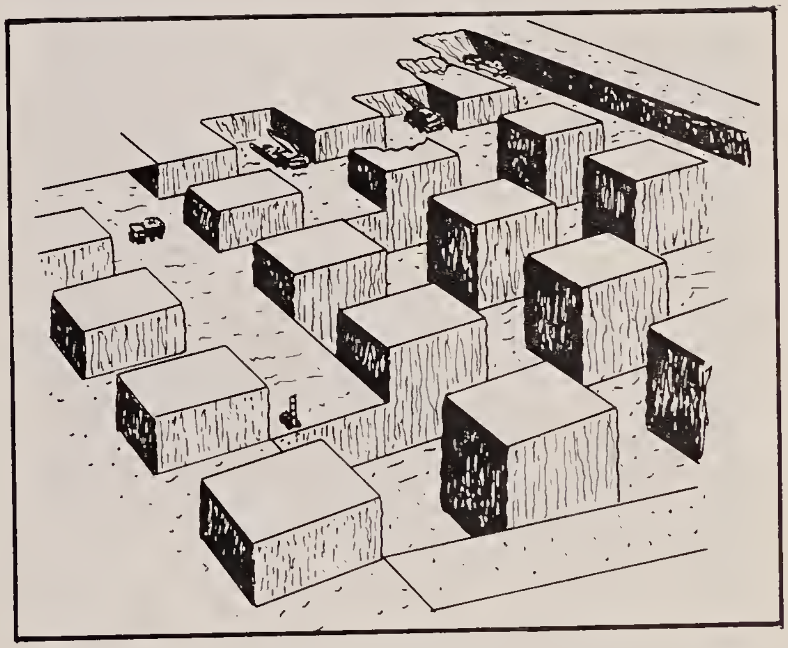
Oil shale is really a case of arrested development — you could say it is oil that never quite made it. Oil shale was never subjected to the enormous pressures and temperatures over geologic time which are needed to convert solid organic matter to liquid petroleum. So the oil in oil shale is not liquid; it is a solid waxy material called kerogen.



The trick to recovering synthetic crude oil from oil shale is to do what nature did not do, that is, heat it to 900 degrees Fahrenheit, where the kerogen breaks down. At 900 degrees, the kerogen in oil shale — technically not shale but a marlstone — distills out as oily gases and vapors, part of which will condense to a material similar to crude oil with the remainder as gas of varying quality depending on the retorting method used. This shale oil is further treated to remove nitrogen, sulfur, and certain heavy metals that would be harmful to refinery equipment, which then yields a high grade synthetic crude oil.

Oil Shale Processing Schemes

There are basically two methods — with numerous variations and combinations — of getting shale oil out of oil shale. One involves direct mining and then retorting in a facility at the surface, while for the other, oil shale is fractured or "rubblized" and retorted in the ground or "in situ."



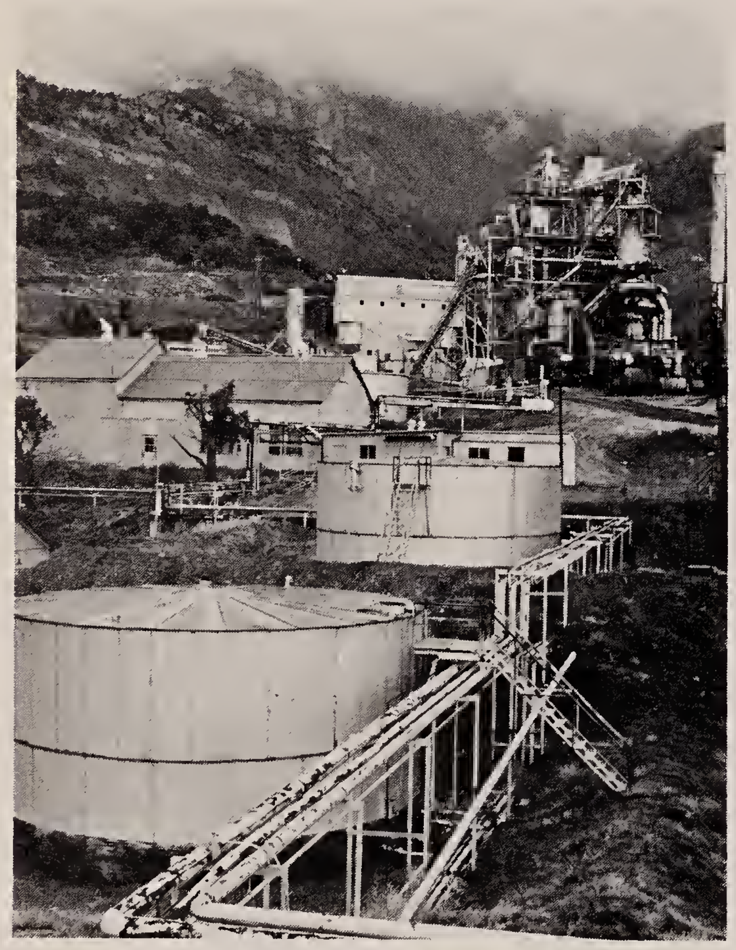
Conventional room-and-pillar mining may be used to extract oil shale for surface retorting.

The first method has been tried at near-commercial scale. Since 1944 conventional underground room-and-pillar mining and surface retorting have been practiced on an experimental basis at Anvil Points, Colorado.

The word is "big" when it comes to describing an underground oil shale mine needed to feed a commercial-scale, 50,000-barrel-per-day operation. Such a mine would be required to produce at least 70,000 tons of raw shale daily. This is larger than the largest underground mine in the United States.

Plans for developing tracts U-a and U-b call for this kind of underground mining and surface retorting. When developed, the project may boast the largest underground mine in the world.

Large-scale surface mining methods could be used where the overburden depth is not too great relative to the thickness of recoverable oil shale.



Oil storage tanks (foreground), and crusher facility and retort (background) at the Anvil Points experimental site.

A surface mine needed to feed a commercial-scale operation would rival or exceed the largest open pit metal mine in the United States. Such a pit when developed would resemble an oval slot up to several miles in length, a mile wide at the top, 2000 feet wide at the bottom, and 1000 to 2000 feet deep. The pit would move by mining one side and backfilling the opposite side.

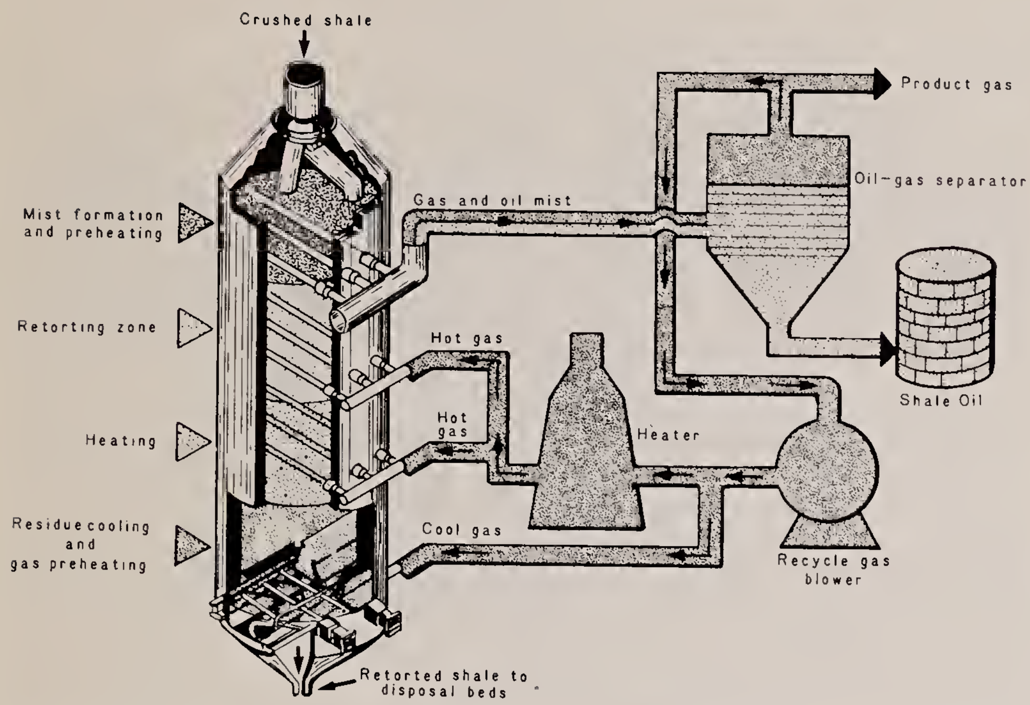
The overburden and waste produced to form the pit would have to be permanently stored on the surface outside the mining area.

Surface retorting

Whether mined by surface or underground methods, raw shale would be retorted in surface installations. In a surface retort plant, raw shale is first crushed, then continuously fed into the retort vessel, and brought to 900°F, retorting temperature, by contact with either hot gases or solids.

Hot gases may be generated directly inside the retort vessel by burning residual carbon left on the shale after the oil is driven off. These hot gases may also be generated externally in heaters. Hot solids are always generated outside the retort vessel. One method involves heating spent shale by burning its residual carbon and recycling this hot processed shale to the retort. Another process uses heated ceramic balls.

Oil vapors are swept out of the retort by the gas stream and sent to recovery processes where oil, gas, and water are separated and recovered. Processed shale is continuously withdrawn from the retort vessel, cooled, moistened, and sent to disposal areas.



Example of a surface retort scheme. Oil shale is mined by surface or underground means and crushed before feeding into retort vessel.

Underground mining of oil shale, Anvil Points.

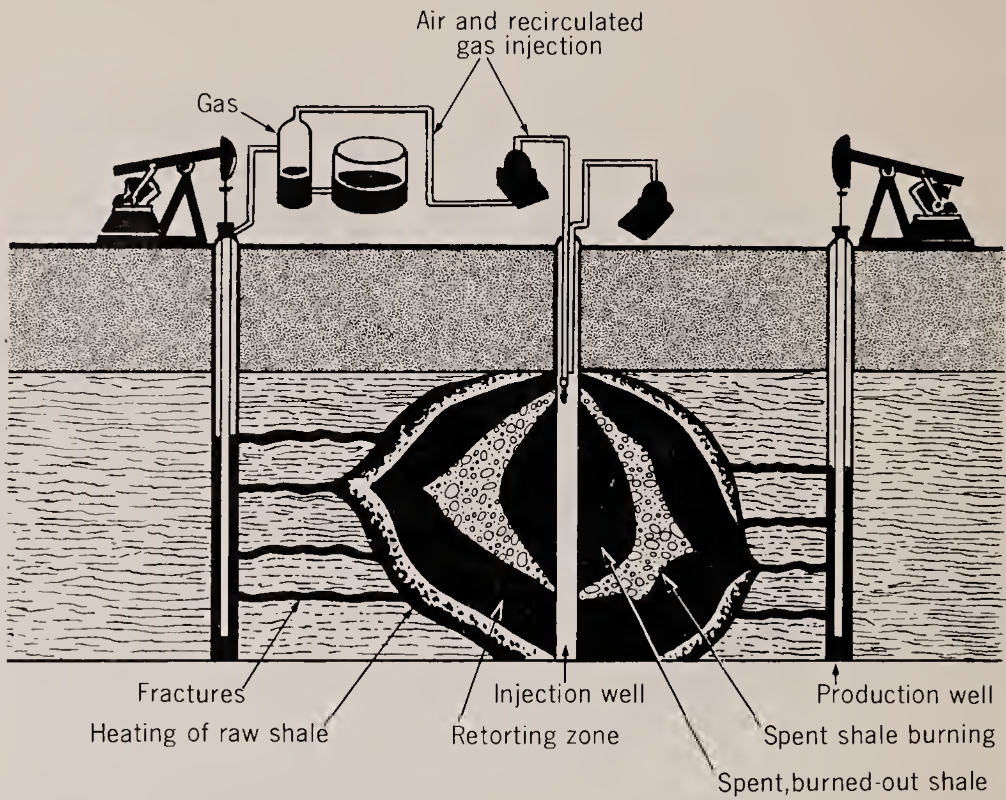
Initially, surface disposal seems the only practical means of dealing with processed shale.

The processed shale would be placed in natural depressions and gulches, compacted with mechanical equipment, and covered with native overburden and soil. A productive plant community would be seeded and managed until a self-sustaining cover crop was achieved.

In situ retorting

An experimental method that in certain areas could eliminate the need for direct mining, surface retorting, and surface waste disposal is the so-called "in situ" method. Here, the oil shale beds are pierced by a regular pattern of drill holes.

Oil shale specimen showing naturally extruding kerogen. In the backgound, surface retort at Anvil Points. (Dept. of Energy photo.)



Example of in situ retorting of oil shale, showing heat retorting and driving product oil within the ground to production wells.

Production shaft headframe (313 feet high) and concrete storage tanks on lease C-b.

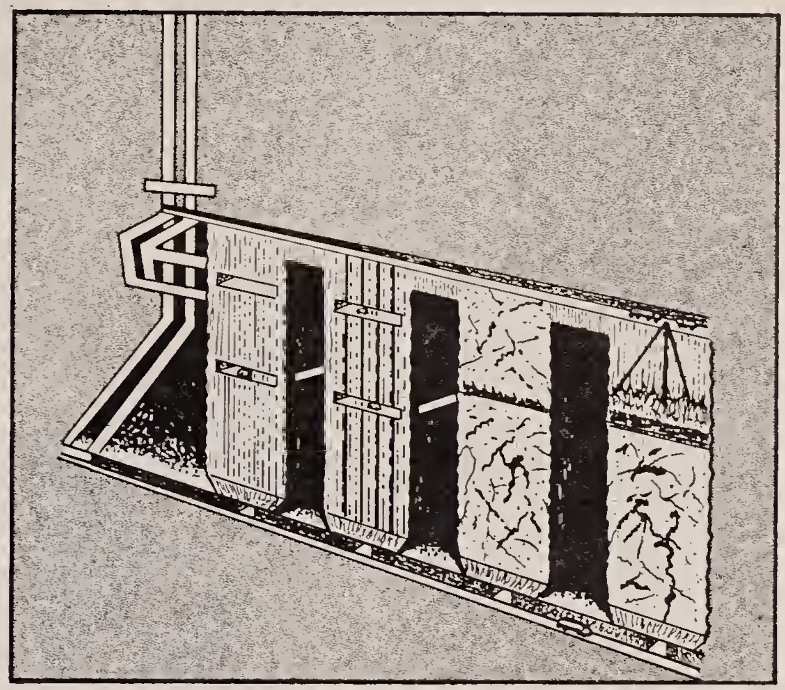
The oil shale between these drill holes is fractured by explosive or hydraulic methods. A flame front or externally heated gases are then forced between succeeding drill holes by differential pressure, retorting and driving product oil and gas to production wells where they are drawn off and treated on the surface to remove water and other contaminants. One company in Utah is attempting to use microwaves to retort shale in situ.

A potential advantage of in situ compared to direct-underground or surface mining and surface retorting is less water consumption — a critical feature in semiarid oil shale country.

Modified in situ

Both Colorado lessees currently plan to use open pit and modified in situ methods of recovering shale oil, combined with surface retorting. With the modified in situ method, retorting is done underground in vertical chimneys of rubblized oil shale. But a significant amount of oil shale — about 20 to 40 percent — is mined and brought to the surface in developing the retort chimneys. This material is then processed by surface retorting methods.

Each retort chimney will be several hundred feet on a side and better than 300 feet high. Based on 57,000-barrel-per-day production, it will take nearly 60 years to completely retort the first 300-foot-thick zone beneath 5,000 acres on tract C-b. It will yield approximately 1.2 billion barrels of oil, to which can be added another 500 to 600 million barrels if all the mined shale is surface retorted.



Example of modified in situ retorting, showing chimneys of rubblized oil shale formed by mining part of the oil shale to be surface retorted.

Developing Lease Management Expertise (Objective No. 4)

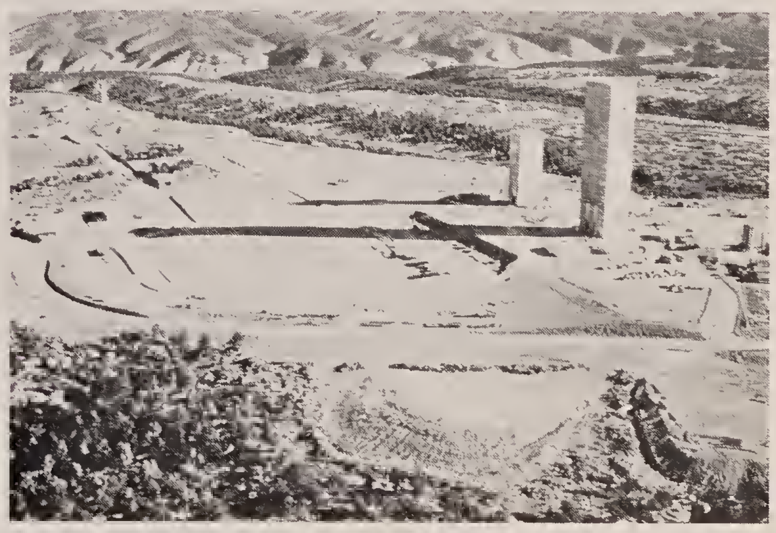
The fourth objective of the Prototype Oil Shale Leasing Program — to develop administrative expertise in the management and supervision of oil shale leases — summarizes the efforts of the Oil Shale Office. Among the tools being developed by the Oil Shale Office are manuals for the various aspects of oil shale lease management. For example, procedural manuals have been written for reviewing and approving Detailed Development Plans and environmental monitoring programs and for lessee annual report evaluations, lease inspections, bonus payment offsets, and royalty accounting.

Lease Contract

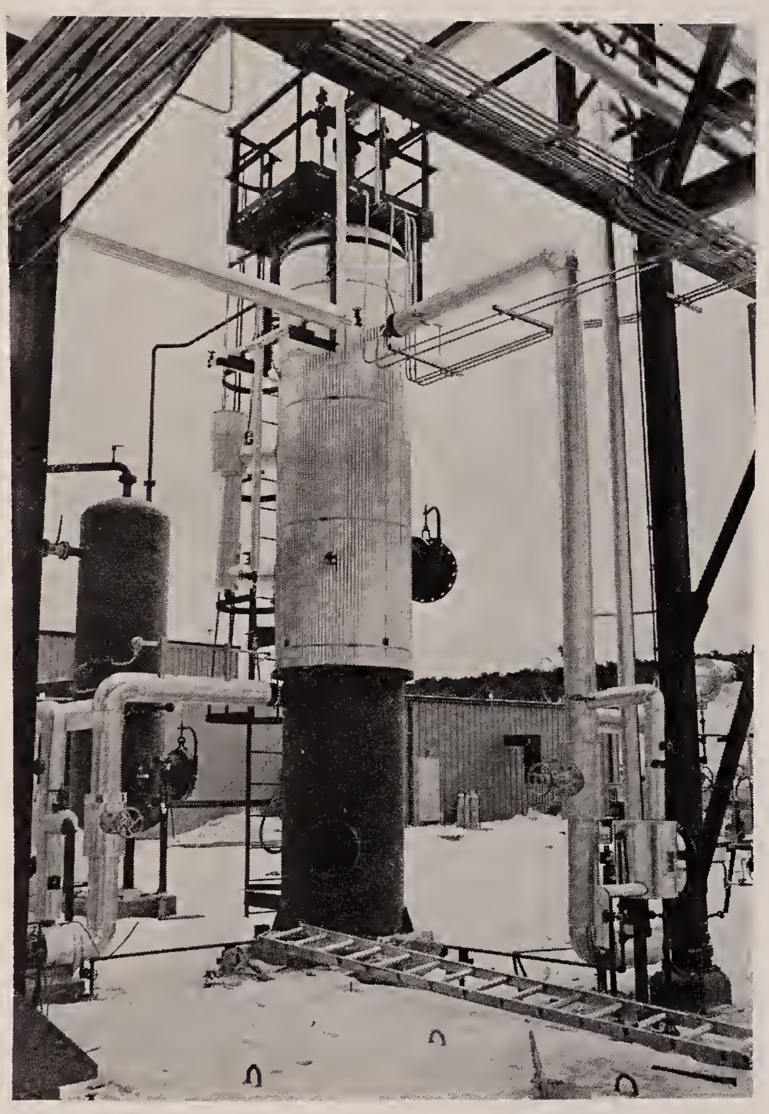
The lease contract, along with the leasing and mining regulations for Federal lands, comprise the basis for the Minerals Management Service's duties.

The first part of an oil shale lease contract contains the normal legal requirements of any mining lease, including conservation requirements, prevention of waste and protection of other resources from damage, diligence requirements, and payment of royalties.

However, unique to an oil shale lease are the environmental stipulations, which comprise the second part of the lease contract. Because there are no precedents for oil shale leasing, these environmental stipulations are written to convey general intent. They do not spell out rigid methodology or specifications, and they grant broad discretion to the Oil Shale Office.



Aerial view toward the northeast across mine development area on tract C-b. Headframes stand over some of the largest commercial mine shafts in North America, extending downward nearly 2,000 feet.



Piping at gas processing facilities on lease C-a.

Review of Plans and Inspections

To ensure that these lease requirements and various Federal and State rules are being followed, Minerals Management employs basically the same two methods in supervising oil shale leases as in overseeing any mineral development on Federal lands:

- Review and approval of lessee's plans for developing and producing a lease, and
- Onsite inspection of lease operations to see that approved plans are being followed.

The task of reviewing plans does not end with approval of the detailed development and environmental monitoring plans. Lessees are continually modifying their methods of development with experience and testing, and all changes in these plans must be approved by the Oil Shale Office.

In addition, because of the prototype nature of the program, a large effort is directed at reviewing, validating, and evaluating data for all aspects of lease operations in order to report on oil shale development, modify development and monitoring plans, and change lease environmental stipulations.

Decisions on lessees' plans have to be made in a timely and expeditious manner, since delays are costly. Because of the tentative and experimental nature of oil shale development, flexibility in decisionmaking must be a watchword.

Leases are being inspected every one to two weeks by the Oil Shale Office, depending upon the amount of activity at each project. An inspection manual provides a checklist of specific items to look for, particularly in potential problem areas.

In addition to regular mining and processing practices, inspectors look for such things as meteorological, hydrological, and biological conditions in the area, whether revegetation schemes are successful, and whether environmental monitoring equipment and techniques are functioning properly.

Inspectors note items of concern and discuss them with lessees. They may find more serious violations which result in enforcement actions from a "notice of noncompliance" to partial or complete suspension of operations until the situation is corrected.

Management studies revealed that a single individual, called a tract coordinator, was needed to coordinate activities for each lease. This was necessary because of the unique nature of each lease operation and the extensive day-to-day involvement of the Oil Shale Office staff in lease operations.

Conclusion

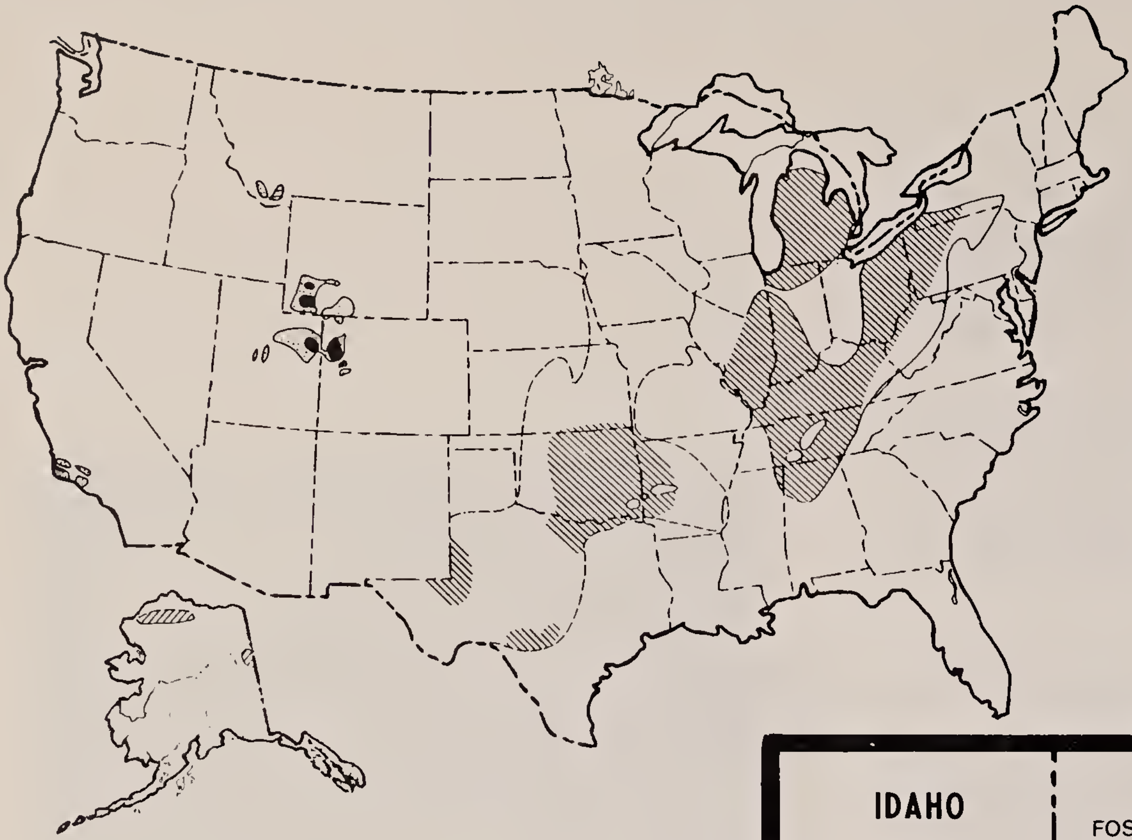
The Minerals Management Service and lessees are cooperating closely to meet all four of the Prototype Oil Shale Leasing Program objectives.

In the final analysis, it will be private industry that determines whether recovery of this sleeping giant of an energy resource is economical.

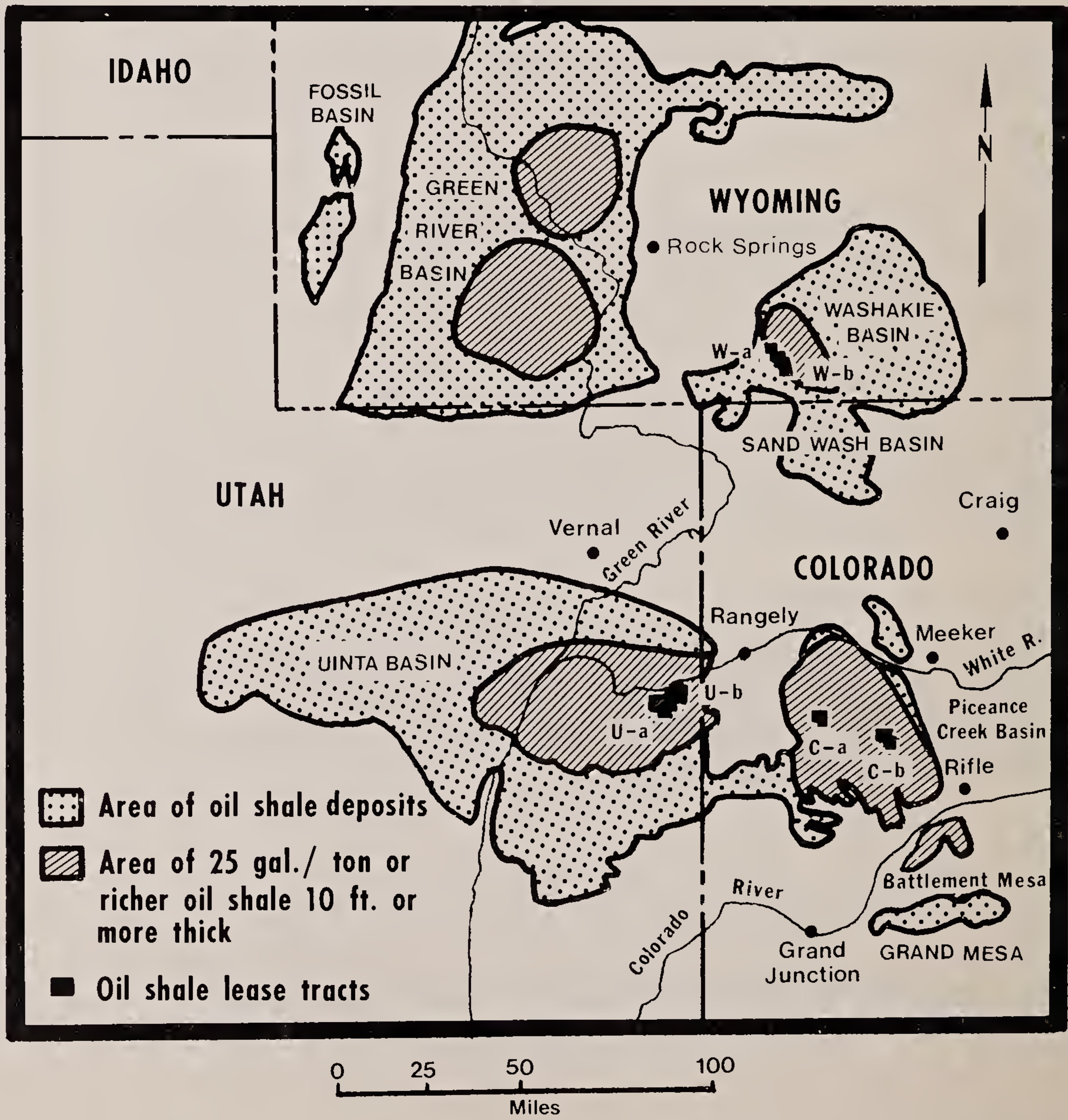
The Green River oil shale is estimated to contain more than 1.8 trillion barrels of oil, of which 600 billion barrels are considered recoverable with present technology. At any rate, that is more oil than all the proven reserves in the Middle East combined.

By efficient management of the prototype program and careful supervision of lease development, the Minerals Management Service is working to stimulate an oil shale technology which will be economical and environmentally sound and will offer a vast new source of domestic energy.

This balanced rock outcrop on tract U-b near the eastern edge of the Uinta Basin of eastern Utah is typical of some of the scenery to be found in the area.



Principle reported oil shale deposits of the United States. The eastern half of the country has extensive deposits, indicated by the hachured areas on the map (dashed line indicates areas where boundary is concealed or uncertain). Alaska, California, and Montana also have oil shale deposits. But some of the richest oil shale is in the Green River Formation of Colorado, Utah, and Wyoming, with the high-grade areas indicated in black. Some 1.8 trillion barrels of oil are estimated to lie within these deposits.



Oil shale areas offered for leasing in Colorado, Utah, and Wyoming are shown as C-a and C-b, U-a and U-b, and W-a and W-b, respectively. Bids were received only for the Colorado and Utah tracts, which were leased in 1974 under the Prototype Oil Shale Leasing Program. Minerals Management Service is supervising development of the leases through its Oil Shale Office located in Grand Junction, Colo.

GPO 837-621

A Brief Chron

1694	British patent for process
1838	First commercial France
1850	Scottish oil shale ir
mid–1800's	Small-scale U.S. oil
1872	General Mining La claims
1920	Mineral Leasing A leasable mineral
1930's	U.S. oil shale deposit quality determined
1971	Prototype Leasing Pr terior Department r tions
1973	Oil shale leasing pro [illegible] Impact Statement pu[illegible]
1974	Colorado and Utah oil shale tracts leas[illegible] Oil Shale Office establish[illegible] Minerals Management Service
1977	Detailed Developmen [illegible] for Colora[illegible] leases approved
1982	Detailed Development [illegible] r Utah le[illegible] approved